NASA Sounding Rocket Program

Unique Opportunities for Low-cost, Fast-turnaround, Focused Scientific Research

Launch of NASA Black Brant XII Sounding Rocket

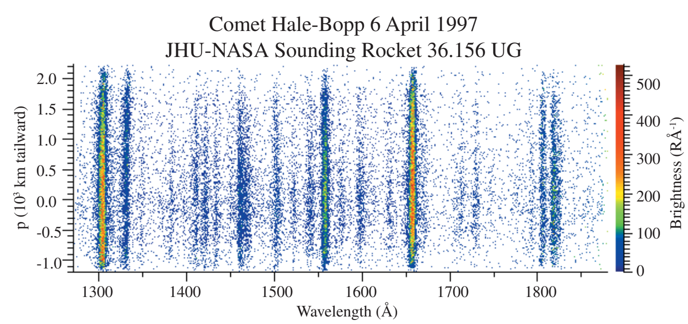
Microgravity • Space Physics • Astronomy • Planetary Science • Earth Science

Unique Opportunities for Scientific Research. Sounding rockets carry scientific instruments into space along parabolic trajectories, providing nearly vertical traversals along their upleg and downleg, while appearing to "hover" near their apogee location. Whereas the overall time in space is brief (typically 5–20 minutes), for a well-placed scientific experiment launched into a geophysical phenomena of interest, the short time and low vehicle speeds are more than adequate (in some cases they are ideal) to carry out a successful scientific experiment. Furthermore, there are some important regions of space that are too low to be sampled by satellites (i.e., the lower ionosphere/thermosphere and mesosphere below 120 km altitude) and thus sounding rockets provide the only platforms that can carry out direct in situ measurements in these regions. Astronomy, solar, and planetary science missions include sophisticated telescopes with optional joy-stick operated, sub-arc-second pointing for >5 minute continuous observations of astronomical objects, including those too close to the sun for Hubble or EUVE observations. Microgravity missions are carried out on high-altitude, free-fall parabolic trajectories which provide ideal microgravity environments without the vibrations frequently encountered on human-tendered platforms.

Low-cost Access to Space. Because the science payload does not go into orbit, sounding rocket missions do not need expensive boosters or extended telemetry and tracking coverage. As a result, mission costs are substantially less than those required for orbiter missions. Furthermore, because the program is managed and the payloads are built in one central location (i.e., the NASA/Wallops Flight Facility), significant savings are realized through efficient, cost-effective operations that procure parts and rocket motors in large quantities and utilize past designs of sub-systems for follow-on missions. In other words, the sounding rocket program takes advantage of a high degree of commonality and heritage of rockets, payloads, and sub-systems flown repeatedly. In many cases, only the experiment — provided by the scientist — is changed. Costs are also very low because of the acceptance of a higher degree of risk in the mission (compared to orbital missions), although safety is never compromised. In some cases (such as almost all astronomy, planetary, solar, and microgravity missions), the payloads are recovered and thus the costs of the experiment and sub-systems are spread out over many missions.

Rapid, Quick-turnaround. Not only are sounding rocket missions carried out at very low cost, but also the payload can

Image of Comet Hale-Bopp, courtesy W. Johansson.



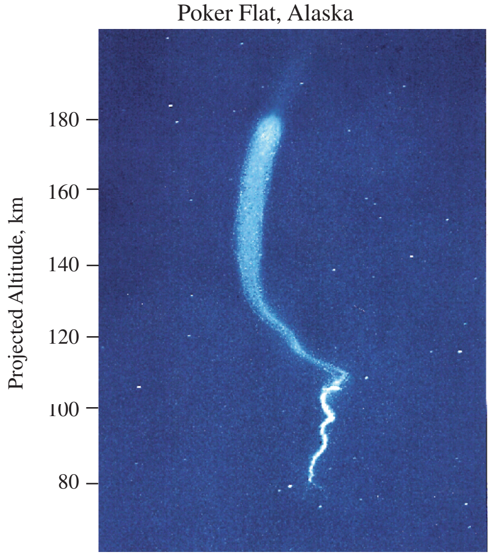
Long-slit spectral image of Comet Hale-Bopp acquired by instruments built by the Johns Hopkins University and flown on a NASA sounding rocket. The long axis of the slit was oriented along the Sun-comet line and was offset 20 arc-seconds from the nucleus. Each pixel is 0.6 Å by 0.8 arc-seconds and subtends 800 km at the comet. The strongest spectral features correspond to atomic oxygen (1302 Å), ionized carbon (1335 Å), atomic carbon (1561 and 1657 Å) and atomic sulfur (1807-1826 Å). The remaining emissions are bands of the carbon monoxide Fourth Positive system. (Courtesy of P. Feldman/JHU).

be developed in a very short time frame — sometimes as quickly as 3 months! This rapid response enables scientists to react quickly to new phenomena (such as observing the Shoemaker-Levy comet impact to Jupiter) and to incorporate the latest, most up-to-date technology in their experiments.

Validating New Instruments and Developing New Technology. The sounding rocket program continues to serve as a low-cost testbed for new scientific techniques, scientific instrumentation, and spacecraft technology, eventually flown on numerous satellite missions. For example, COBE, CGRO, EVUE, FAST, ASTRO-2, UARS, SOHO, TRACE, and numerous other recent NASA Satellite missions have been enabled by technology and experimental techniques developed in the suborbital program. Furthermore, the low cost of sounding rocket access to space fosters innovation: instruments and/or technologies which are not sufficiently developed to warrant the investment of satellite-program-scale funding are often "proto-typed" with initial space testing on sounding rockets.

Education. In addition to science and technology, sounding rockets also provide invaluable tools for education and training. For example, a three-year sounding rocket mission at a university provides an excellent research opportunity for a Ph.D. dissertation, in which the student carries the project through all of its stages — from conception to hardware design to flight to data analysis and, finally to the publication of the results. This "hands on" approach provides the student with invaluable experience of understanding the space flight mission as a whole. Indeed, over 350 Ph.D.'s have been awarded as part of NASA's sounding rocket program.

Summary. One of the most robust, versatile, and cost-effective flight programs at NASA, the Sounding Rocket Program provides critical scientific, technical, and educational contributions to the nation's space program.



Luminous trail of tri-methyl aluminum reveals neutral wind shears, gravity waves, and Kelvin-Helmholtz instabilities in the high-latitude, lower thermosphere. (Courtesy of M. Larsen/Clemson Univ.)

Wallops Flight Facility. NASA's Sounding Rocket program is managed and implemented at the Wallops Flight Facility on Virginia's Eastern Shore. Established in 1945, Wallops is a national resource for providing low-cost integration, launch, and operations of suborbital and small orbital payloads that support NASA's Earth Science and Space Science Enterprises.

To Learn More. For more information, contact Mr. P. Eberspeaker, Chief, Sounding Rockets Program Office, NASA Wallops Flight Facility, Wallops Island, VA, 23337. Tel: (757) 824-2202. E-mail: Philip.J.Eberspeaker@nasa.gov. (http://www.wff.nasa.gov/~code810/)

Scientists interested in carrying out research projects on sounding rockets should contact the appropriate science discipline scientist at NASA HQ (http://www.hq.nasa.gov/). Missions are selected on the basis of peer-reviewed proposals and available funds. Additional information may be found on the Sounding Rocket Web page (http://rscience.gsfc.nasa.gov/).

Unique Features of Sounding Rockets

- Only platforms that provide direct access to the Earth's mesosphere and lower thermosphere (40 - 120 km).
- Quick, low cost access to high altitudes where astronomical observations can be made of radiation at wavelengths absorbed by the Earth's lower atmosphere.
- Provision of several minutes of ideal, "vibration-free" microgravity.
- Ability to observe astronomical sources close to the Sun (e.g., Venus, Mercury, comets near perihelion) that are too close for Hubble or EUVE observations.
- Ability to gather *in-situ* data in specific geophysical targets such as the aurora, the cusp, the equatorial electrojet, noctilucent clouds, thunderstorms, etc.
- Portability provides access to remote geophysical sites and southern hemisphere astronomical objects.
- Slow vehicle speed with respect to the ambient medium (and much slower than that of orbiting satellites).
- Collection of vertical profiles on upleg and downleg.
- Long dwell times at apogee.
- Ability to fly simultaneous rockets along different trajectories (e.g., with different apogees, flight azimuths).
- Ability to fly numerous free-flying sub-payloads from a single launch vehicle, as well as tethered payloads.
- Ability to fly relatively large payload (>500 kg) masses on inexpensive vehicles.
- Ability to recover and refly instruments.
- Rapid response times.
- Low cost.